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Civil Engineering Heritage Country Profile - Scotland

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Abstract:	<p>This paper is a review of Scotland's civil engineering heritage, one of the series of national profiles being published by Engineering History and Heritage. It is presented under four headings: Scotland's major civil engineering achievements; National and regional recognition of its engineering heritage; Exemplar conservation of engineering structures; and Information sources for engineering heritage. The paper discusses engineering structures of heritage importance including six UNESCO World Heritage sites as well as many mediaeval masonry bridges; harbours and ports developed since the 18th century by engineers such as Rennie, Telford, James Walker, William Cubitt, and James Rendel; many lighthouses and canals; dams built for feeding canals, water supply and hydroelectric power; bridges by Rennie, Telford, Smeaton, Stevenson, Benjamin Baker as well as modern structures such as the innovative suspension bridge over the Forth by Mott Hay and Anderson and Kylesku Bridge by Arup. The paper lists organisations in Scotland active in helping to conserve its engineering heritage, including Historic Environment Scotland which also publishes guidance on extending the life of structures. The paper concludes with a short list of websites and books giving further information about Scottish civil engineering heritage.</p>
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ICE Journals

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Dear Sirs,

I am pleased to submit the journal article “Civil Engineering Heritage Country Profile – Scotland” for consideration in your Engineering History and Heritage Journal.

Yours sincerely

Prof Gordon Masterton

Chair of Future Infrastructure, University of Edinburgh

HEAD of SCHOOL: Professor Hugh McCann FREng
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Civil Engineering Heritage

Country Profile - Scotland

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Abstract

This paper is a review of Scotland's civil engineering heritage, one of the series of national profiles being published by Engineering History and Heritage. It is presented under four headings: Scotland's major civil engineering achievements; National and regional recognition of its engineering heritage; Exemplar conservation of engineering structures; and Information sources for engineering heritage. The paper discusses engineering structures of heritage importance including six UNESCO World Heritage sites as well as many mediaeval masonry bridges; harbours and ports developed since the 18th century by engineers such as Rennie, Telford, James Walker, William Cubitt, and James Rendel; many lighthouses and canals; dams built for feeding canals, water supply and hydroelectric power; bridges by Rennie, Telford, Smeaton, Stevenson, Benjamin Baker as well as modern structures such as the innovative suspension bridge over the Forth by Mott Hay and Anderson and Kylesku Bridge by Arup. The paper lists organisations in Scotland active in helping to conserve its engineering heritage, including Historic Environment Scotland which also publishes guidance on extending the life of structures. The paper concludes with a short list of websites and books giving further information about Scottish civil engineering heritage.

1. Scotland's major civil engineering achievements

The earliest evidence of man-made shelter is the 5,000 year old settlement at Skara Brae, part of the Neolithic Orkney World Heritage Site. Relics of larger scale civil engineering survive from the Roman occupation, especially the Antonine Wall (c. 142 AD), a 60 km long turf wall and ditch with forts and a parallel military road built across the narrowest part of Scotland between the Forth and Clyde estuaries. For a period of 16 years or so this formed the north western frontier of the Roman Empire.

The earliest monastic buildings were at Whithorn (5th Century) and Iona (563AD) of which minimal physical evidence survives, the sites being built over by the Benedictines in the 13th Century. Larger scale building in Scotland began in the reign of Malcolm Canmore (1058-1093) and his Benedictine monastery at Dunfermline

1 was constructed by Master Aelric, probably from Saxon England through connections of Malcolm's queen
2 Margaret. In King David I reign (1124-1153) more than 12 new monastic settlements were established
3 including Abbeys at Selkirk, Kelso, Holyrood, Jedburgh, St Andrews, Cambuskenneth and Melrose. The
4 outer fabric of many of these early buildings still survives. Much of the northern and western coastal areas
5 were still occupied by Vikings and a 12th Century Viking shipyard, connected to the sea by a canal, has
6 recently been re-discovered on Skye.
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8 Evidence of mediaeval bridges in Ayr (1234), Dunkeld (1252), Berwick (1281), Haddington (1282), Dumfries
9 (1283), Glasgow (1285), Stirling (1296), Perth (1303), and Aberdeen (1310) is documented in Charters and
10 other contemporary references. (Years are the earliest when a bridge is referred to, not the unknown date of
11 construction).
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15 In 1580, after the Reformation and transfer of assets from monasteries, George Bruce was granted a lease
16 to restore the colliery at Culross in Fife, and embarked on an impressive scheme of undersea mining. He
17 built an artificial stone and clay-lined bund in the sea from which a shaft was sunk with shipping berths
18 alongside to export the coal (Figure 1). An Egyptian wheel of buckets was used for draining the mine. With
19 his adjacent salt pans, this was the most sophisticated industrial complex of its time, some 150 years earlier
20 than the industrial revolution.
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25 James Watt, the greatest engineer of the industrial revolution, was born in Greenock in 1736 and some
26 physical evidence of his early career in Scotland remains, notably the model Newcomen engine for which he
27 demonstrated his separate condenser now held by the Hunterian Museum, Glasgow. The cottage in which
28 he developed the full scale prototype steam engine remains in ruins close to Kinneil House, the home of his
29 patron John Roebuck, owner of the Carron Iron Works.
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34 Before road and rail links were developed, water routes provided the principal means of access and trade.
35 Trading with the Low Countries and Scandinavia was mainly from the ports of the Forth and the Tay, and as
36 tobacco became an increasingly valuable commodity, Glasgow overtook Bristol and Liverpool as the centre
37 of that 18th Century trade, with engineering being instrumental in its success through the improvement of
38 navigation of the Clyde from a fordable river to a shipping channel. James Stirling in 1752 and John
39 Smeaton in 1755 were commissioned for advice but it was John Golborne, a canal engineer in James
40 Brindley's "school", who recommended in 1768 that the river be constrained by a series of lateral dykes,
41 allowing self-scouring to deepen the channel, with localised dredging to remove obstacles. This succeeded
42 and by 1775 the Clyde had a depth of seven feet into the centre of Glasgow.
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48 The Board of Trustees for the Encouragement of Fisheries, Manufactures and Improvements in Scotland, an
49 18th Century equivalent of Scottish Enterprise, proposed a canal across Scotland between the Forth and the
50 Clyde with a branch to Glasgow. Smeaton, Golborne and Watt were all involved in early plans and in 1768
51 work began and by 1777 Glasgow was well connected to its markets for incoming and outgoing trade by
52 waterway. Robert Whitworth took over from Smeaton after he retired in 1785 and completed the western end
53 of the Forth and Clyde Canal by 1790, allowing navigation across Scotland. In 1803 Thomas Telford
54 recommended to the British Fisheries Society that The Caledonian Canal (Figure 2) be built on the line of the
55 Great Glen, and that new roads be built connecting the Highlands to the north and south. This ambitious plan
56 led to twenty years of construction and was an economic lifeline for the Highlands.
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Harbours developed continuously from the 18th century and the large ports of Leith, Greenock, Port Glasgow, Aberdeen, Peterhead and Dundee attracted the greatest engineers of their time. Rennie, Telford, James Walker, William Cubitt, James Rendel, all feature, but ports are fiercely utilitarian and early work can be difficult to discern. The older fishery harbours, now leisure amenities, of Crail, Elie, Portpatrick, and Eyemouth and many others, have retained more of the charm of their 18th century heyday.

With its experience in Canal reservoir building, Scotland was quick off the mark with water-supply systems. The earliest dam built in the UK solely for water supply is the Whinhill Dam (1796) for the supply of Greenock. Today it is 245m long and 12m high. Glencorse Dam (1823) by Telford and Jardine is 165m long and 24m high, the first to be built for the supply of Edinburgh. The system was later widened with five more earth dams by the middle of the 19th century, following much the same pattern as Telford's solid design, and most recently by Megget Reservoir (1983), retained by Scotland's largest earth dam. Glasgow's fast growing water supply needs were satisfied by constructing a 36km aqueduct from Loch Katrine in 1859, designed by La Trobe Bateman, and another in 1901. The hydro-electric developments of the 20th century led to the first concrete dams. Arch dams were built at Tongland (1934), Earlston (1936) and later Monar (1962). The dam for the Loch Sloy scheme (1950) was a concrete buttress dam, as was Errochty (1955). The largest, Mullardoch (1952) was a mass concrete gravity dam. The most revolutionary however was Babbie Shaw and Morton's 24m high prestressed concrete dam at Allt-na-Lairige (1956) 80km north of Glasgow (Figure 3). A series of vertical rods are anchored deep into rock close to the water face. It was the first of that type in the world and used only 60 percent of the concrete required for a gravity dam.

Lighthouses have a special place in Scotland's engineering heritage. The earliest known navigation beacon was on the Island of May in the Forth (1636), but a 1786 Act established the Commissioners of Northern Light Houses who appointed Thomas Smith as their engineer beginning a remarkable family association over four generations continuing with his step-son, Robert Stevenson, from 1799 and then Stevenson's three sons and two grandsons. Notable examples of more than 80 major lights designed by the Stevenson family are Pentland Skerries (1794); the Bell Rock (1811) in conjunction with John Rennie; Tarbat Ness (1830); the majestic 42m high Skerryvore (1842); North Ronaldsay (1852); and Bass Rock (1902).

Roman roads built in south and central Scotland formed the basis of later routes, and by the 14th Century there is evidence of gravelled roads good enough for wheeled carts. Soldiers built a military road network north of Glasgow and Stirling, including numerous stone arch bridges, in two campaigns in the 18th Century. The first was led by General Wade and the second by Major William Caulfield. Primarily to facilitate military control over disaffected Jacobite areas, they also provided trading routes. In the late 18th and early 19th Century, road building was stimulated by the Turnpike system allowing Trustees to levy tolls to recoup costs, complemented by the Commissioners' 'Parliamentary Roads' in the Highlands. Notable surviving bridges of the period include Smeaton's bridges at Coldstream (1767) and Perth (1771), Rennie's Kelso Bridge (1803), Telford's bridges at Dunkeld (1808), Craigellachie (1815), Cartland Craggs (1822) and Dean Bridge Edinburgh (1831), and Stevenson's New Bridge at Stirling (1832).

The coming of railways transformed the landscape. The earliest were coal carrying routes between coalfields and canals, such as the Monkland and Kirkintilloch (Thomas Grainger, 1826). The Edinburgh Glasgow passenger line was opened in 1842. John Miller's Ballochmyle viaduct in Ayrshire (1850) is the highest masonry arch bridge in Britain. Arterial routes and branch lines sprung up apace and the fierce competition

between the North British Railway and the Caledonian Railway for the fastest route from London to Aberdeen fuelled the growth. The great estuary crossings of the Forth and Tay were progeny of the race to the North. But the collapse in a gale in December 1879 of Thomas Bouch's Tay Bridge (1878), killing 75 people, was the nation's worst engineering disaster. Bouch's design for a Forth Bridge was promptly abandoned, and Fowler and Baker engaged to design the world's heroic icon of Victorian engineering, using the new material, steel, in vast quantities in its three giant cantilevers (Figure 4). Both the Forth Bridge (1890) and W.H. Barlow's replacement Tay Bridge (1887) were built by Sir William Arrol and Company, establishing the firm as the world's leading bridge builders.

Dramatic rail routes in the north were built with scant sources of local materials, leading Robert McAlpine (Concrete Bob) to use mass concrete to build bridges and viaducts for his West Highland Line and other railways, the curved, multi-span Glenfinnan Viaduct (1901) being the most picturesque. The stations at Edinburgh Waverley (1902, mainly) and Glasgow Central (1905) are the most impressive of some fine designs.

In the 20th Century, the Great North Road was rebuilt in the 1920s offering opportunities to showcase the relatively new structural material, reinforced concrete, in the innovative hands of Owen Williams at Tomatin (1926) and Blyth and Blyth's elegant arch at Grantown-on-Spey (1931). The post-war motorway and trunk road programme led to Mott, Hay and Anderson's Forth Road Suspension Bridge (1964), then the fourth longest span in the world, which became a modern counterpart to its neighbour and in 2017 a cable-stayed bridge by Arup/Jacobs, will be a third addition to the canon of great bridges at this unique site. Freeman, Fox and Partners designed the Erskine cable-stayed bridge over the lower Clyde (1971) and the box girder Friarton Bridge (1978) near Perth. Those, and W.A. Fairhurst's prestressed concrete Kingston Bridge (1970), Babbie's Baillieston Interchange (1980), Hellmut Homberg's Kessock Bridge (1982), Arup's Kylesku Bridge (1984), Miller-Dywidag Skye Bridge (1995) and Babbie's cable-stayed River Leven Bridge (1995) are the most notable of the 20th Century bridges, although many other shorter span attractive bridges were built in the rural settings of the borders and the north, particularly over the Annan River, the Nith at Dumfries, Helmsdale, and Clunie Bridge over Loch Faskally.

For such a mountainous landscape, Scotland has relatively few long tunnels. The hydro-powered aluminium works at Kinlochleven (1907), with a young William Halcrow as assistant resident engineer, being a notable early example. James Williamson's design for Cruachan pumped storage scheme (1965) built to operate in tandem with Hunterston A Nuclear Power Station (1964), required a huge underground turbine hall to be excavated. The only underground railway in Scotland is the Glasgow Subway (1896), engineered by Simpson and Wilson, the third oldest in the world. The Clyde is also crossed by Glasgow Harbour Tunnel (1896) (originally for pedestrians but now only for utilities) with its distinctive rotunda surface structures and Halcrow's Clyde Tunnel (1964) carrying road traffic.

The centre of manufacturing engineering in Scotland has been Glasgow and the Clyde with shipbuilding, locomotives, engines of all types, armaments, airships, pumps, cars, steel bridges and crane-building together forming the core of an important industrial powerhouse for at least 150 years. The civil engineering infrastructure necessary for these industries was significant. Every shipbuilding yard required launchways, berths, docks, and every large scale engineering production factory required long-span sheds. Robert Napier built the largest ship in the world for Samuel Cunard (RMS Persia, 1855) at the Lancefield Works, and John

1 Elder's design for the Fairfield shipyard (1858), still in use, was the first integrated shipbuilding yard which
2 within 10 years employed 4,000 people. William Beardmore, owner of the Parkhead Forge, acquired Napier's
3 yard in 1900 and built an engineering conglomerate employing 40,000 people at its peak. Little physical
4 evidence remains, except through the naming of shopping centres, hospitals or hotels on the sites. Easton,
5 Gibb's substantial naval dockyard at Rosyth (1916) is now in private hands, currently assembling two aircraft
6 carriers, the largest ships yet built in Scotland. The 1927 art-deco office of the India Tyre factory at Inchinnan
7 was built on the site where airships were built, and remains in use. Architecturally interesting factories were
8 built for Arrol-Johnston cars at Heathhall, Dumfries (1913), and the all-woman Galloway car factory in
9 Tongland (1917).

12 The 1970s saw a heavy engineering renaissance as the exploitation of North Sea oil and gas required huge
13 fixed offshore platforms. Both concrete gravity and steel tubular braced jackets were used, most constructed
14 in Scotland.

18 Scotland's intensely active engineering community in civil, mechanical, manufacturing, electrical and
19 shipbuilding, ably underpinned by educational and research giants such as Kelvin, Rankine and Clerk
20 Maxwell, was nurtured by extremely effective networking, facilitated in part by the multi-disciplinary Institution
21 of Engineers and Shipbuilders in Scotland, founded by Rankine in 1857.

2. National and regional recognition of engineering heritage

29 Historic Environment Scotland (HES) is the public body with charitable status responsible for leading and
30 enabling strategy in the historic environment, caring for over 300 properties, and surveying, collecting,
31 curating and archiving records of the built environment, including an international collection of aerial
32 photography with over 20 million images. HES provides technical expertise, training and guidance in
33 traditional skills and conservation, and promotes community and individual learning engagement with
34 Scotland's heritage. It also administers a grant scheme for qualifying conservation proposals. Since October
35 2015 it incorporates the previous Historic Scotland and the Royal Commission on the Ancient and Historical
36 Monuments of Scotland.

42 Scheduled Monuments are protected and administered under the Ancient Monuments and Archaeological
43 Areas Act 1979 (as amended by the Historic Environment (Amendment) (Scotland) Act 2011). HES
44 recommends monuments for scheduling, encourages positive management and controls work on them
45 through the legal consent process. There are over 8,000 in Scotland, many of them with strong engineering
46 content such as industrial mills and anti-invasion defences.

50 Legislation for listed "buildings" is devolved to the Scottish Government under the Planning (Listed Buildings
51 and Conservation Areas) (Scotland) Act 1997 and administered through the Historic Environment Scotland
52 Act 2014. Progressive legislation has been in force since 1882 but the greatest additions to the inventory
53 were made between 1945 and 1970. "Buildings" is defined broadly in the legislation and includes engineered
54 structures such as bridges, harbours, dams, etc. There are around 47,000 listed buildings in Scotland, split
55 into three categories set out in the Scottish Historic Environment Policy 2011: A (national or international
56 importance – around 8% of total), B (regional – 50%) and C (local – 42%).

Local authorities are responsible for designating Conservation Areas, and there are over 600 in Scotland.

Enlightened owners of heritage assets recognise the benefits of conservation and there are some good examples of intervention in railways (through the Railway Heritage Trust), canals (Scottish Canals Trust), water supply, and electricity generation. But there are also many challenges where fiscal responsibility has been devolved to smaller entities which are then unable to cope with the maintenance burden. The grants scheme provides mitigation but local authorities often still experience shortfalls, as exemplified recently by the challenges facing Samuel Brown's Union Chain Bridge (1820) over the Tweed at Paxton, for a brief period the longest suspension bridge in the world and the oldest in the world still carrying road traffic.

3. Exemplar conservation of engineering structures

Scotland currently has six entries on the UNESCO list of World Heritage Sites, most with a string engineering content (election dates in brackets): St Kilda (1986), Frontiers of the Roman Empire (Antonine Wall added 2008), Old and New Towns of Edinburgh (1995), Heart of Neolithic Orkney (1999), New Lanark (2001) an industrial community of cotton mills, hydro power, housing and education and The Forth Bridge (2015), the world's earliest great multispan cantilever bridge, and an "extraordinary and impressive milestone in the evolution of bridge design and construction during the period when railways came to dominate long-distance land travel, innovative in its concept, its use of mild steel, and its enormous scale".

Scotland has five ASCE International Civil Engineering Landmarks (opening dates in brackets): the Forth and Clyde Canal (1768-90), Caledonian Canal (1804-22), Craigellachie Bridge (1814), the Forth Bridge (1890), and Arrol & Co's Titan Crane at Clydebank (1907), a monument to the River Clyde's past glory as, for 150 years, the world's largest shipbuilding centre.

The Institution of Civil Engineers and the Saltire Society have collaborated since 1981 in the Saltire Awards for Civil Engineering for which there are categories for design, conservation, sustainability and construction. The categories can overlap but notable conservation and heritage-related projects recognised include: re-opening of the Borders Railway (2015); Haymarket Station capacity improvement (2015); refurbishment of Waverley Station (2014); Linlathen East Bridge (2012); Scotstoun No. 2 Dock upgrade (2008); the Tay Bridge Refurbishment (2003); Portrack Railway Bridge Realignment (2004) and Buccleuch Bridge, Dumfries (1983). The overall winner for the first 25 years in 2005 was the Falkirk Wheel. After a period of closure, the canals in central Scotland received Millennium funding and since 2002 the Forth and Clyde Canal has been a navigable waterway across Scotland. The link between Edinburgh and Glasgow is made through its connection to the Union Canal by the Falkirk Wheel, an iconic example of modern engineering, helping to revitalise heritage assets.

Scottish projects are also eligible for the various UK awards, one of which, the British Construction Industry Awards was inspired by the Saltire Scheme.

The ICE Historic Bridge and Infrastructure Awards were founded in 1998 and notable Scottish projects recognised include: strengthening of Glasgow's Kingston Bridge (opened 1970); restoration of Linlathen East Bridge, and the 2012 restoration work on the Forth Bridge.

1 The earliest heritage project to be recognised in these award schemes, Buccleuch Bridge, Dumfries (Figure
2 5), involved the replacement of corroded parapet girders, 19th century additions to a bridge which had been
3 widened from an 18th century five span masonry arch. In the 1930's further changes were made when the
4 arch fill was removed and replaced with a cellular reinforced concrete arch structure, whose deck was found
5 to be badly deteriorated and a new slab deck overlay was designed to retain as much usable structure as
6 possible. The new girders were designed in structural hollow sections, secured against torsion at each end,
7 to give lateral impact resistance to a modern standard. The cast iron decorative panels were refurbished and
8 refixed. Two spans of the bridge were realigned and widened to give a better route to accommodate long
9 vehicles' swept path. The commendation was made by the Saltire Society "in recognition of environmental
10 harmony and attention to detail of the design with benefit to all road users."

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14 Linlathen East Bridge (Figure 6), twice recognised, is Scotland's oldest surviving iron bridge (c1804) and
15 spans approximately 14m across the Dighty Burn in Dundee. It is constructed of wrought and cast iron with
16 delicate decorative parapets. A digital survey was made of the bridge. All items were tagged and the bridge
17 dismantled section by section. The bridge was mainly bolted together and each bolt was removed by hand in
18 order to be re-used, where possible, in the reassembly. Lead was melted out of the wall fixing sockets, and
19 packing removed. The bridge was removed to a workshop where the wrought and cast iron was thoroughly
20 cleaned (and built up where required), treated and painted. New centre and quatrefoil castings were made
21 along with newly forged handrail hoops. A number of new nuts and bolts were specially made to replace
22 those that had been sheared or were corroded beyond redemption. Cast and wrought metal fixings were
23 insulated from each other and joints protected with lead putty. Re-leading and a final coat of paint completed
24 the works.

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32 A new steel and timber deck was constructed to replace the timber sleeper deck, not thought to be original.
33 Stone abutments were conserved with matched stonework where elements had been lost through
34 vandalism. The bridge has now re-opened to pedestrians and cyclists, forming part of the North East
35 Countryside Core Path and provides valuable access to the two new housing developments in the immediate
36 vicinity. Conservation of the bridge was made a planning condition for these developments, an enlightened
37 approach to achieving the necessary leverage for investment in a significant, but previously redundant, part
38 of Scotland's engineering heritage.

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44 The Institutions of Civil and Structural Engineers formed the Conservation Accreditation Register for
45 Engineers (CARE Panel) in 2004 to complement similar registers for architects and surveyors. Its formation
46 was encouraged and stimulated by Historic Scotland (the Edinburgh Group). The peer reviewed panel now
47 defines the highest standard of competence for engineering in conservation.

4. Information sources for engineering heritage

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53 The authoritative source for engineers and the owners of heritage structures on preservation, maintenance
54 and restoration is HES. It provides definitive guidance on listing, publishes a wide range of books on
55 monuments and conservation and has a large archive of documents and images. It also has a programme
56 of plaques that recognise great individuals in Scottish history (thirty-three installed up to 2015, of which six
57 are engineers: James Watt, John Logie Baird, John Muir, Henry Bell, Hercules Linton and Andrew Baird).
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59 The National Monument Record of Scotland is an archive of drawings, records and photographs of
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Scotland's built environment, and includes engineering and industrial buildings and structures. Much of it is digitised and available through its online portal. <https://canmore.org.uk/>

The Institution of Civil Engineers Panel for Historical Engineering Works (PHEW) maintains a useful, searchable inventory of historic engineering structures, of which 550 are in Scotland. It has published eight Regional Guides covering the UK, two of which relate to Scotland. PHEW Scotland has fixed plaques to many works. <https://www.ice.org.uk/about-us/what-we-do/panel-for-historical-engineering-works>

The Buildings at Risk Register has been in operation in Scotland since 1990 in response to a concern at the growing number of listed buildings and buildings in Conservation Areas that were vacant and had fallen into a state of disrepair. The Register is maintained by Historic Environment Scotland, and provides information on properties of architectural or historic merit throughout the country. <http://www.buildingsatrisk.org.uk/>

The Institute of Historic Building Conservation (IHBC) is the UK's professional body for building conservation practitioners and historic environment experts and seeks to establish, develop and maintain the highest standards of conservation practice, and it has an active Scottish branch. <http://www.ihbc.org.uk/index.html#sthash.2PSB0gj5.dpuf>

The Architectural Heritage Society of Scotland originated from a group formed in 1956 to respond to the threatened demolition of Edinburgh's George Square. It became the Scottish Georgian Society in 1959, and the present name was adopted in 1984 to reflect the broader scope of the Society's activities. It is concerned with the protection, preservation, study and appreciation of Scotland's buildings. <http://www.ahss.org.uk/>

The Scottish Civic Trust is the national body for the civic movement in Scotland. It engages proactively with local civic groups across Scotland and regularly comments and campaigns for the improvement of Scotland's individual buildings and areas of distinction. The Trust seeks to encourage active interest in all aspects of the built historic environment. <http://www.scottishcivictrust.org.uk/>

Members of the Society for the Preservation of Ancient Buildings (SPAB) living and working in Scotland decided to form their own semi-autonomous group in 1995 recognising that Scotland has its own building traditions, architectural language and property laws, all of which are best dealt with locally. <http://www.spab.org.uk/spab-scotland/>

The Scottish Lime Centre Trust in Charlestown, Fife was established in 1994 as a 'not for profit' organisation. Its aims are to promote the appropriate repair of Scotland's traditional and historic buildings; advance education through the provision of advice, training and practical experience in the use of lime for the repair and conservation of such buildings and promote the preservation and development of Scottish traditional building crafts and skills. <http://www.scotlime.org/en/>

The Scottish Engineering Hall of Fame, inaugurated in 2011 by IESIS, Scotland's indigenous engineering Institution since 1857, now has the life stories and key achievements of 23 outstanding engineers who have made a contribution to Scotland's reputation as a seedbed for engineering from 1580 to the present day, and several are inducted each year. <http://www.engineeringhalloffame.org>

Edinburgh's National Museum of Scotland, the National Mining Museum, Glasgow Kelvingrove Museum, Glasgow's Riverside Museum of Transport, Glasgow University's Hunterian Museum, the Scottish Railway Preservation Society, Scottish Maritime Museum, Summerlee Museum of Scottish Industrial Life and Heriot-Watt University's Museum of Civil Engineering own original historic engineering artefacts and hold technical libraries and engineering archives.

The Scottish Industrial Heritage Society provides opportunities to meet and explore a broad range of industrial heritage; from mills to ironworking, heavy engineering to distilling. The Scottish Transport and Industry Collections and Knowledge network (STICK), established in 2006, is an independent subject specialist network with members throughout Scotland from local authorities, universities, voluntary, national and independent museums. <http://www.stickssn.org/site/>

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Figure Captions (images uploaded as separate files)

Figure 1 Culross Moat Pit (c1580). An interpretation of the structural elements © Donald Adamson

Figure 2 Caledonian Canal - Neptune's Staircase © Historic Environment Scotland

Figure 3 Allt-na-Lairige Dam under construction © Babbie Group

Figure 4 The Forth Bridge © Historic Environment Scotland

Figure 5 Buccleuch Bridge, Dumfries. Parapet replaced 1982 as photographed in 2015 © Gordon Masterton

Figure 6 Linlathen East Bridge, Dundee © Historic Environment Scotland

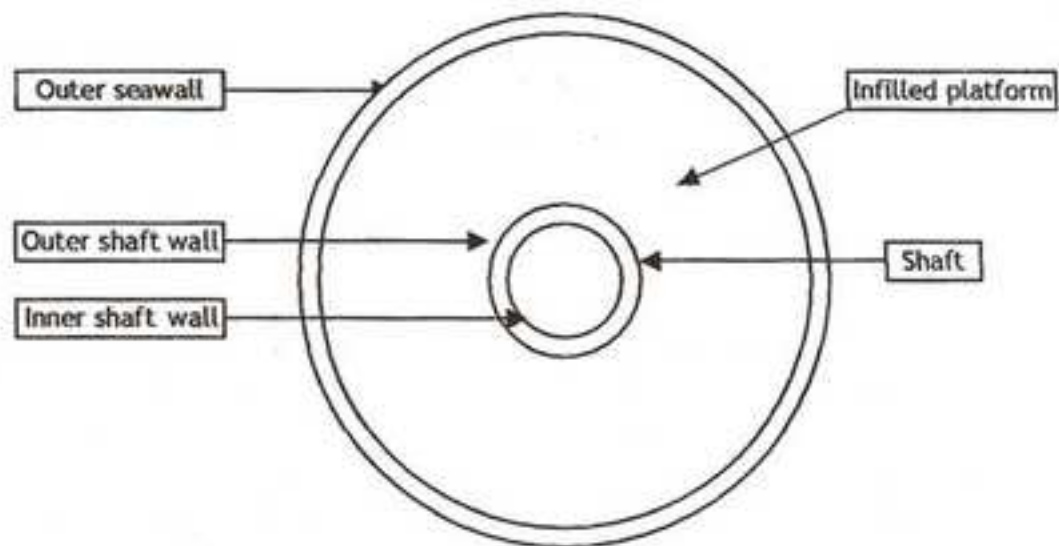
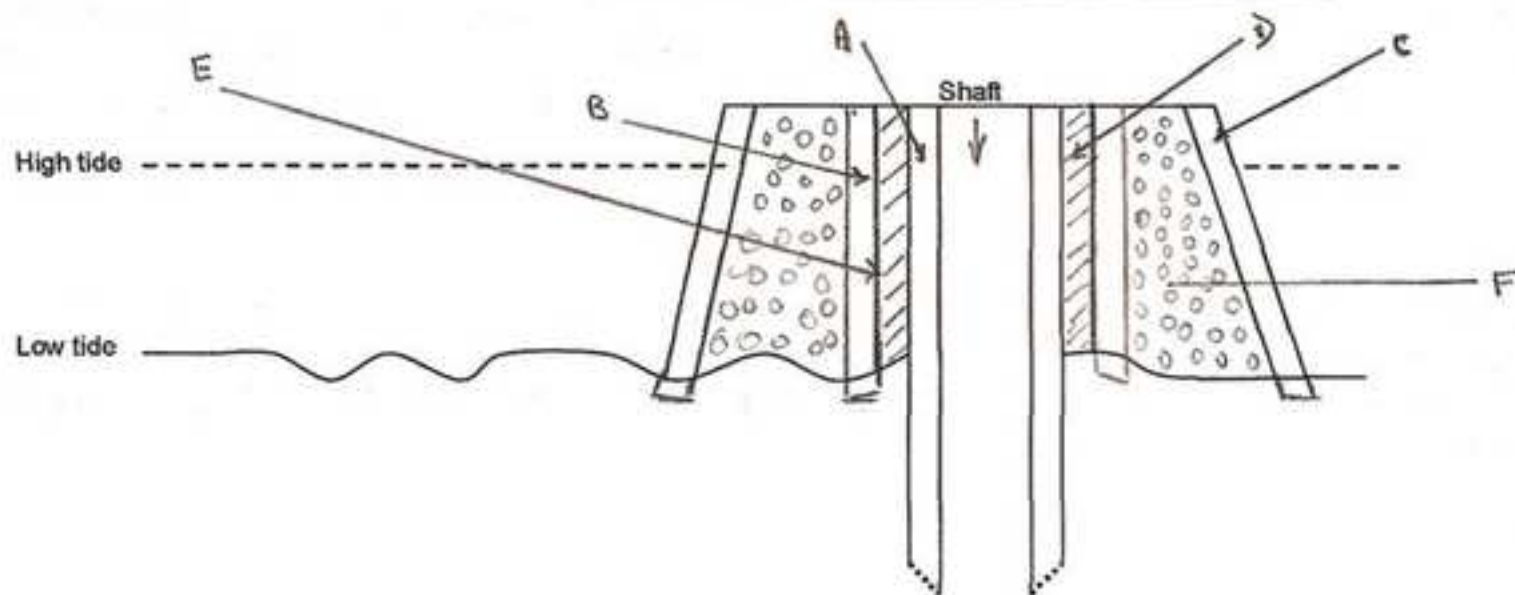
Sketch 1**SKETCH PLAN OF MOAT PIT ISLAND,
CULROSS****SECTION THROUGH MOAT PIT ISLAND**

Figure 2

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Figure 3

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Figure 4

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Figure 5

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Figure 6

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